Changes to EMMA Lattice Specification Since the January Review

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EMMA Design Review
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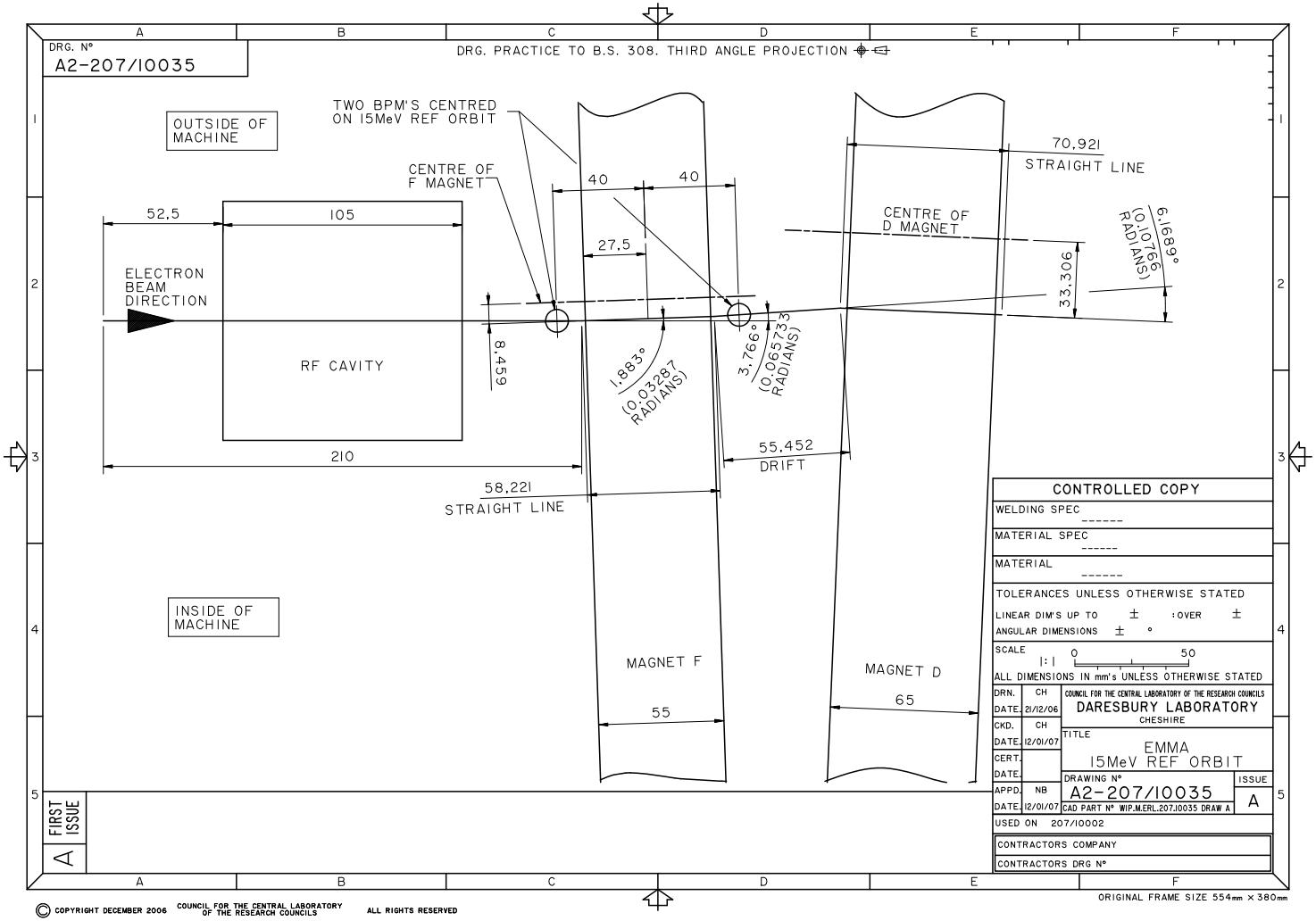
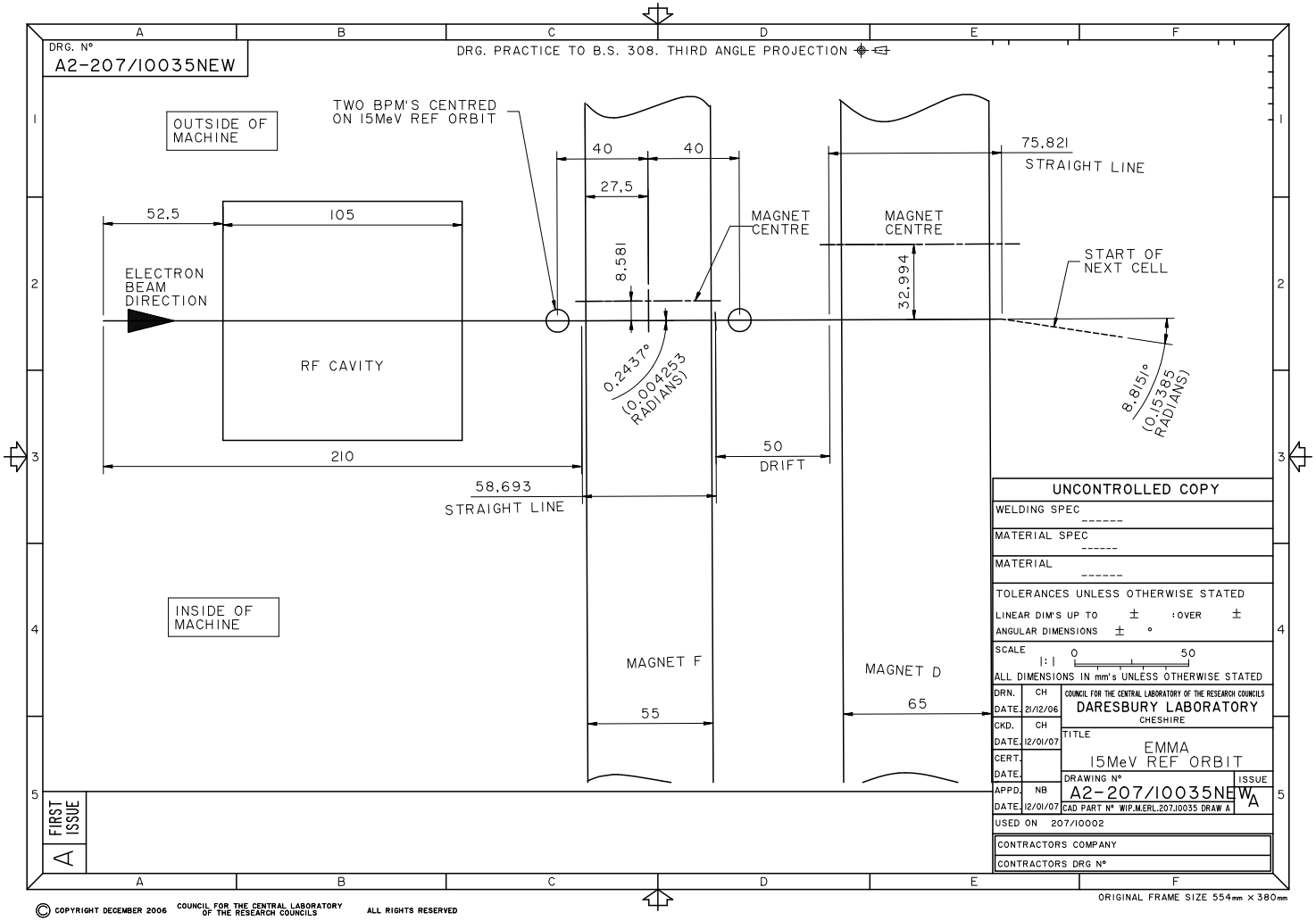
Lattice Evolution from January Review

- At January review: each magnet and cavity had different axis orientation
- Suggestion at that meeting: make magnets parallel
  - Result: little increase in apertures
  - Note that F axis nearly parallel to cavity axis
- Next, made cavity axis parallel to magnet axes
  - Result: again, little increase in aperture
  - This is now the layout we're using

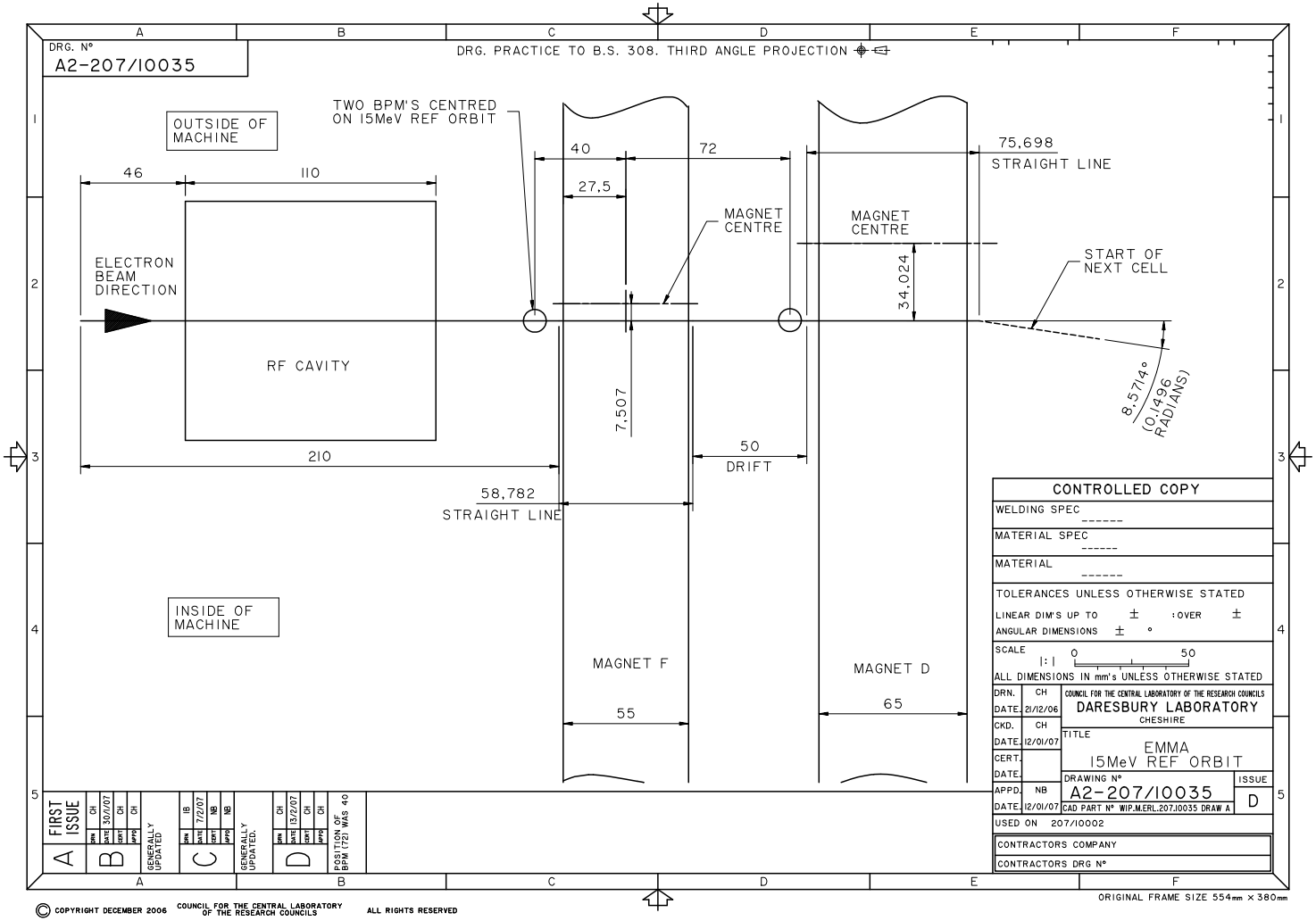
Layout at January Review



Only Magnets Parallel



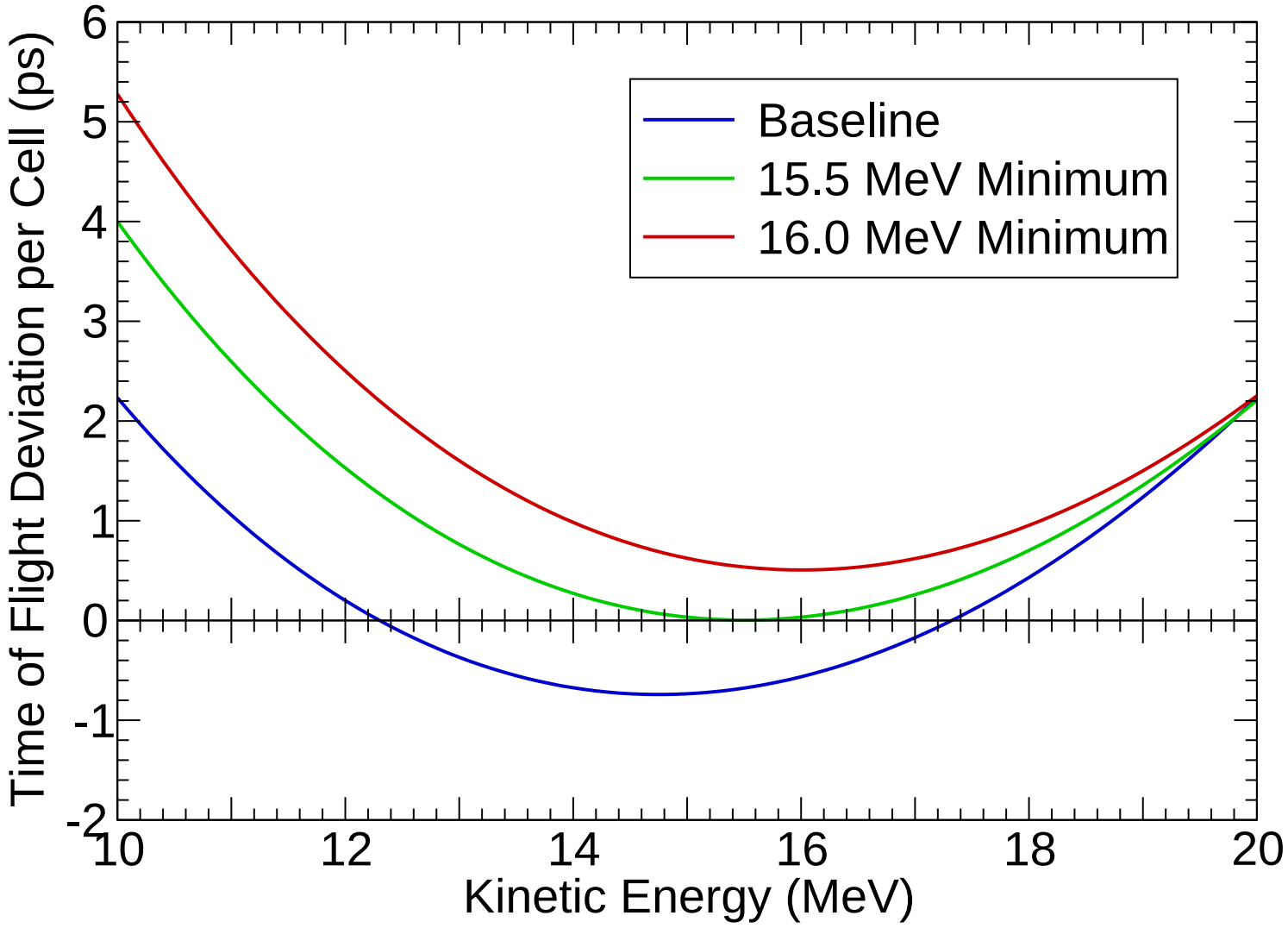
Everything Parallel



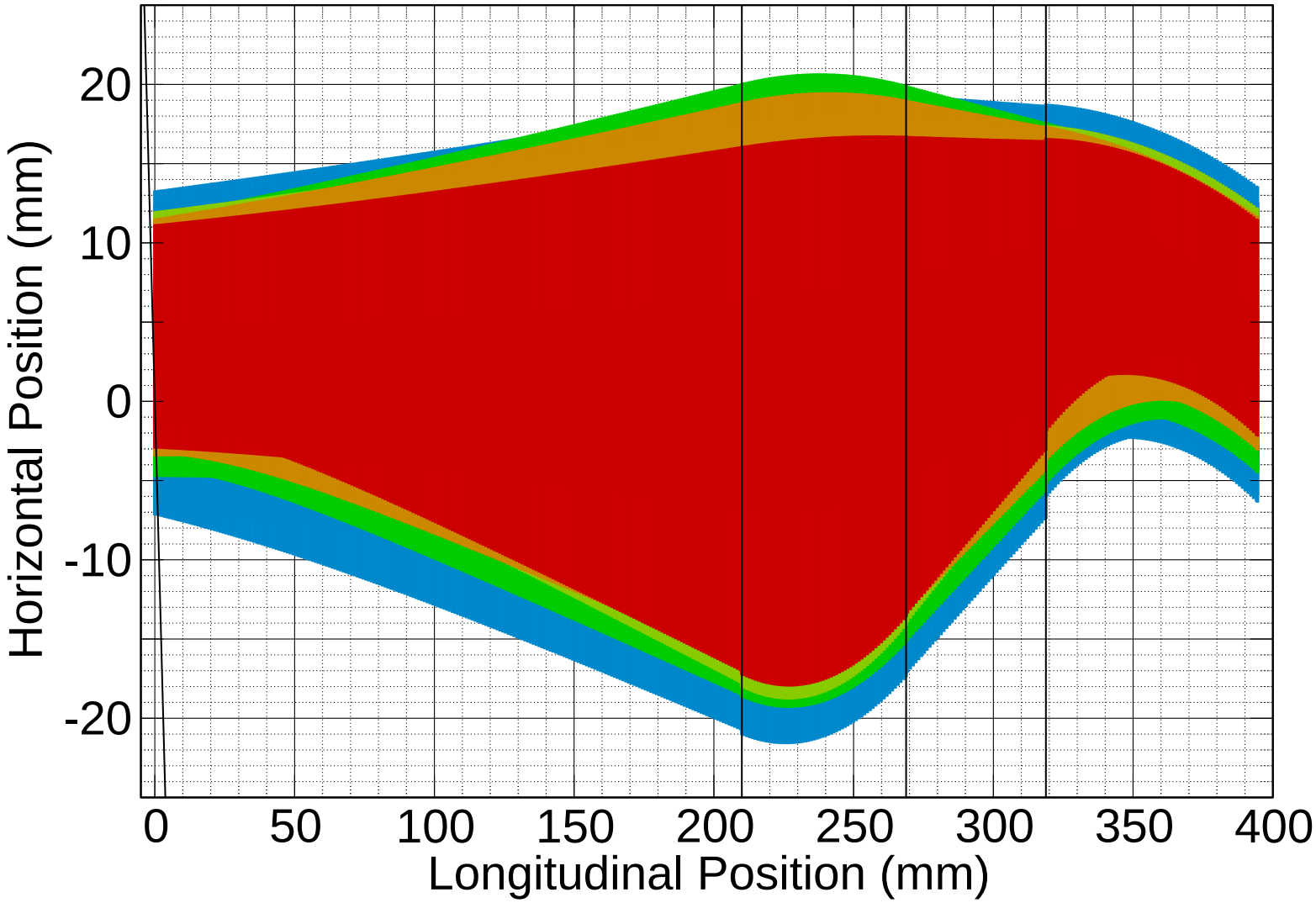
Updates to Analysis

- Frequency of cavities can be set to any energy within acceleration range (commissioning)
  - Wider frequency range required
  - Reduced maximum energy that time of flight minimum would be raised to
    - ⋆ Reduces frequency range required
    - ⋆ Reduces aperture as well
- Cavity shortened to 105 mm (from 175 mm)
  - With current shifted and longer cavity, somewhat pessimistic
- Take into account closed orbit jump at magnet ends
  - Due to hard edge model, but effect is real (but smoother!)
  - Magnet aperture must be increased to this size (D only)
- Minor bugfix in end field handling (effect negligible)

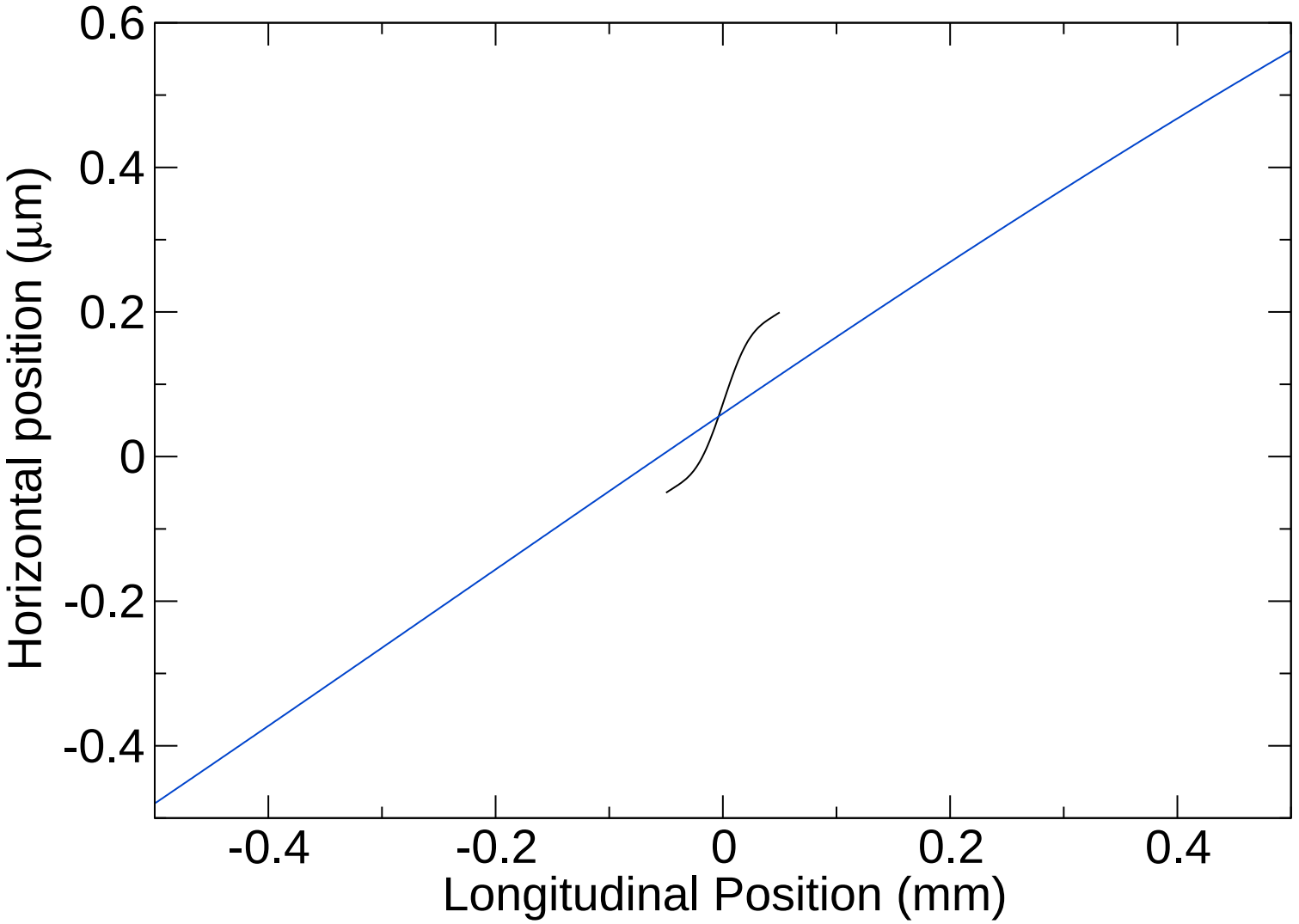
Time of Flight
Different Locations for Minimum



Horizontal Beam Footprint



Beam Trajectory due to End Fields



Making Cavity, Magnets Parallel Geometry

- Coordinate reference length about the same
- Redistribution of lengths (“magnets” longer) and angles
- Orbits do what they will: this is just the coordinate system!

	Before 061213a	After 070221b
Long drift (mm)	210.000	210.000
F entrance angle (mrad)	-32.867	0.000
F length (mm)	58.221	58.782
F exit angle (mrad)	-32.867	0.000
D entrance angle (mrad)	107.666	0.000
Short drift (mm)	55.452	50.000
D length (mm)	70.921	75.699
D exit angle (mrad)	107.666	149.600

Making Cavity, Magnets Parallel
Apertures and Gradients

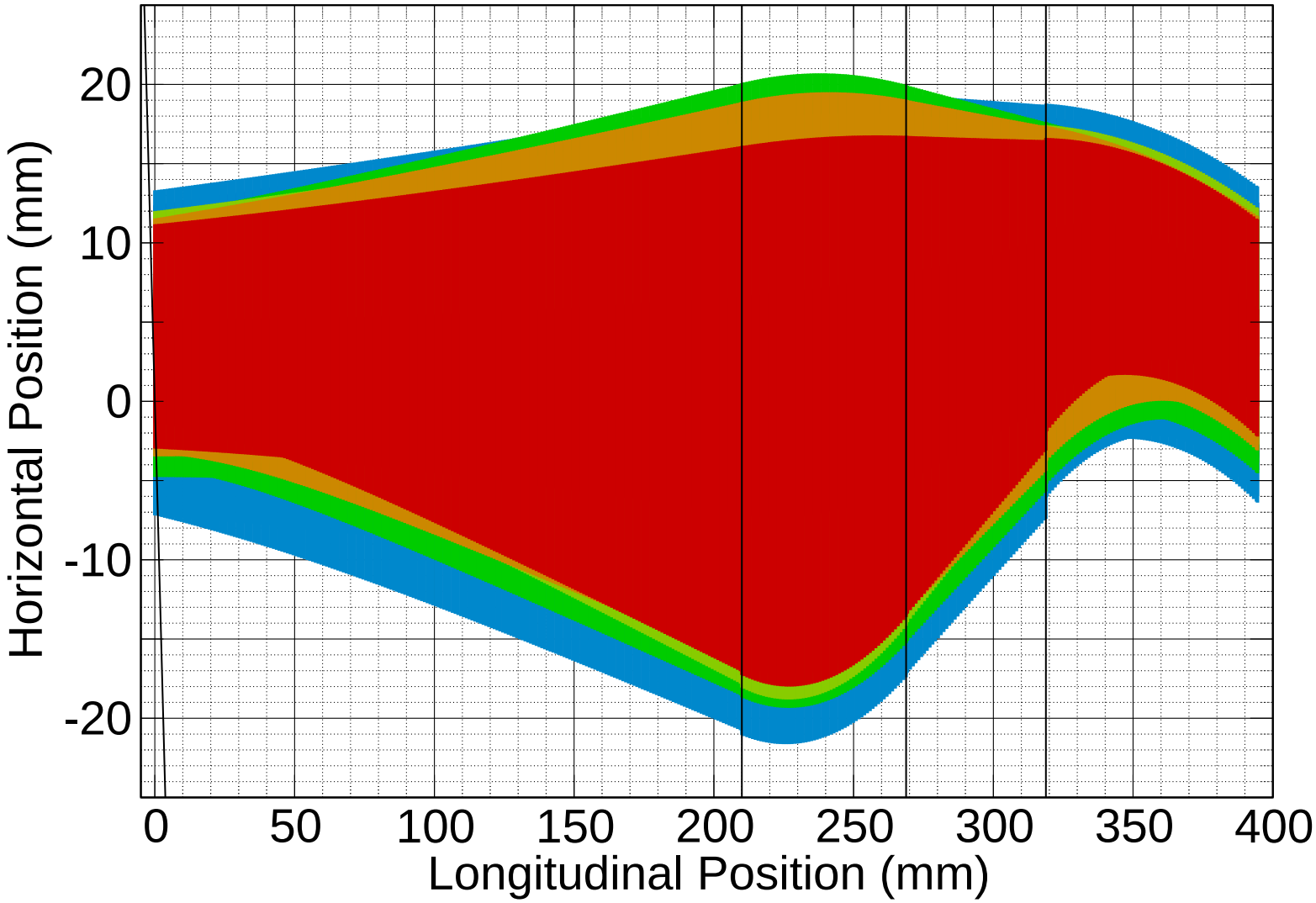
- Aperture, gradient requirements haven't changed much
  - D quad better, frequency range larger (sort of)

	Before 061213[ac-i]	After 070221[b-i]
Cavity full aperture (mm)	38.429×22.256	34.751×21.142
D pipe full aperture (mm)	24.327×23.444	26.205×23.353
F pipe full aperture (mm)	41.955×17.747	42.338×17.813
D quad max (mm)	60.120	55.975
F quad max (mm)	32.166	31.850
D gradient max (T/m)	-5.041	-4.843
F gradient max (T/m)	6.799	6.847
Frequency range (kHz)	3966 (6489)	5574
Ring voltage for $a = 1/6$ (kV)	2220	2286

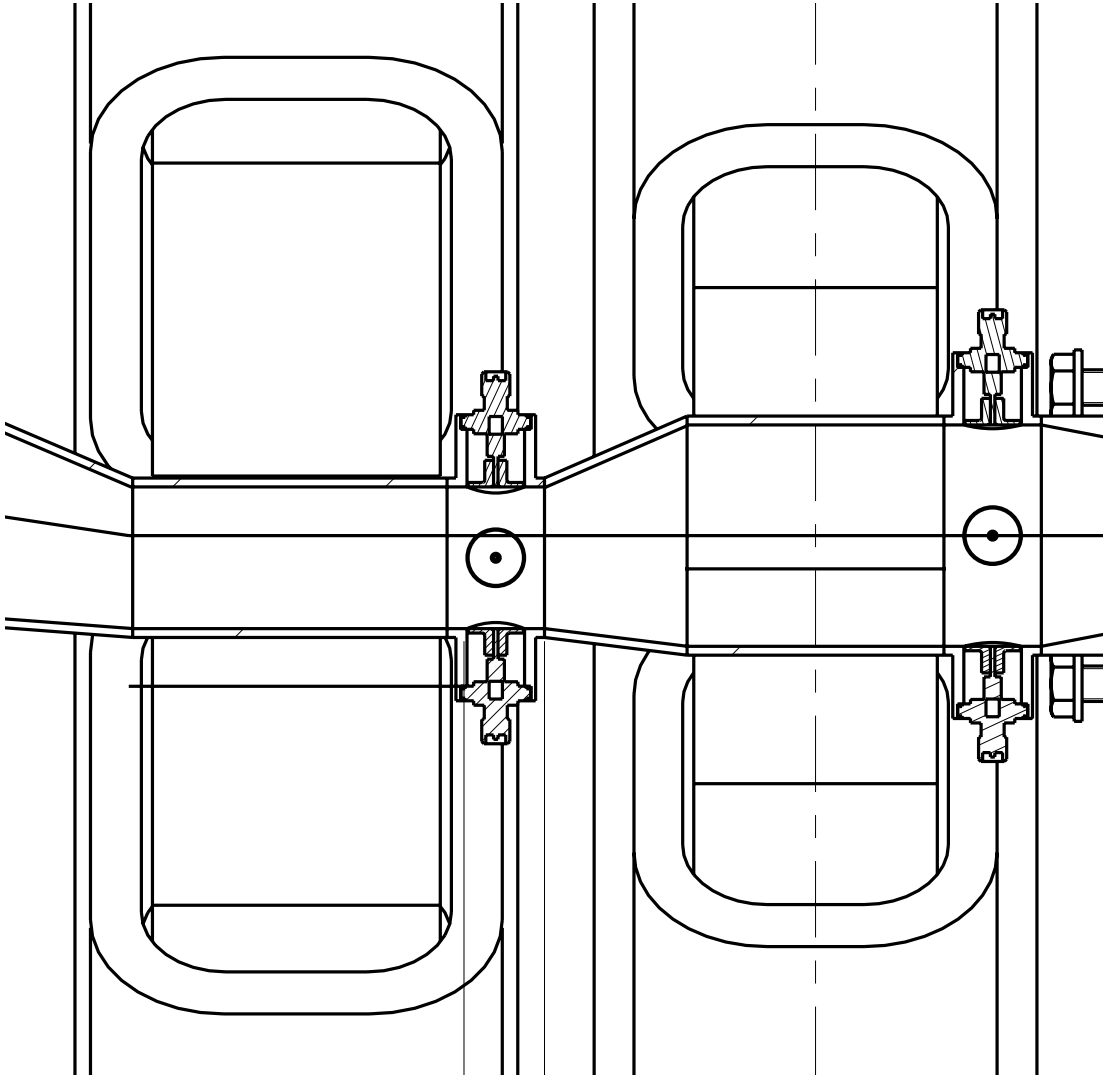
Horizontal Beam Footprint

- Sequence is long drift, F quad, short drift, D quad
- Placing BPM near D quad requires wider pipe aperture
  - Looks like it would require around 3 mm extra width (BPM extends out around 1.8 cm)
  - Not in the above tables

Horizontal Beam Footprint



BPM Close to D Quad



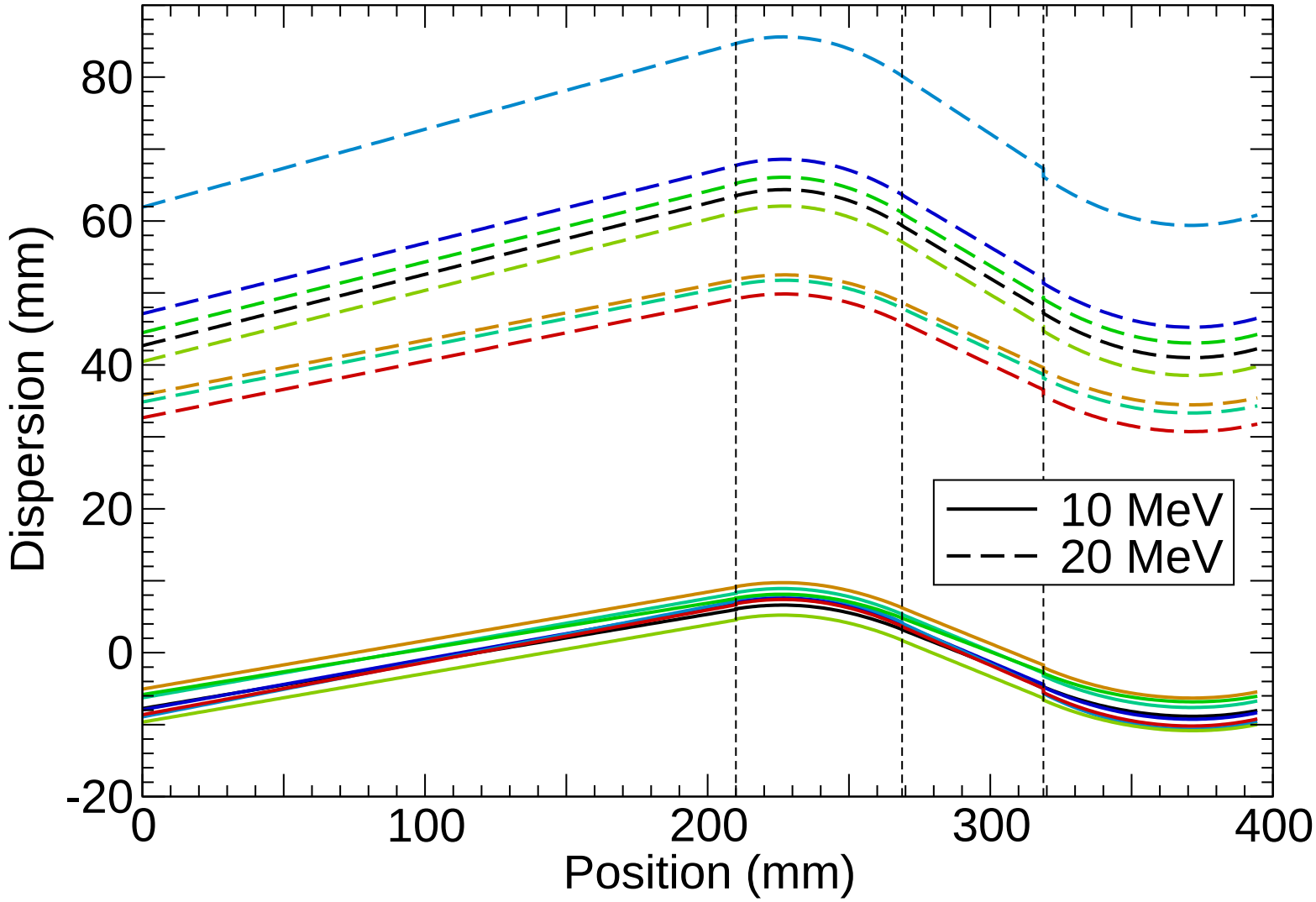
Magnet Lengths

- I am basing analysis on rectangular field profile with lengths specified earlier
- Apertures computed based on this
- Current magnet lengths are a bit arbitrary
  - Probably not important, just an observation. . .
  - Lengths shorter than what I give, so D aperture is better in real life
- Things will be rather different anyhow when we have real magnet field profiles

Dispersion Size

- The things you discover as you're writing talks. . .
- Energy spread in beam gives it a width
- Already accounted for when within the energy range (10–20 MeV)
- However, what about lower energies at injection, higher energies at extraction?
- Guess: 10% energy spread at injection, 5% at extraction

Dispersion


Dispersion (mm)
80
60
40
20
0
-20
0
100
200
300
400
Position (mm)
10 MeV
20 MeV

Dispersion Size Increase in Apertures

- Dispersion very small at injection
  - Plus, it's negative in the D and most of long drift
  - Pushes cavity and F aperture a fraction of a mm
- Dispersion larger at injection
  - Not a big issue for magnets: just widen vacuum chamber
  - Cavity aperture: 3–4 mm
- Reduce acceleration range for testing large longitudinal emittance?

Converting to FODO Lattice

- Use high-horizontal, low-vertical tune lattice to minimize aperture
- Use the F magnets
  - Displacements are 99 mm, -39 mm (normally 5–10 mm)
  - Lower gradients, but just as much dipole
  - Cavity aperture: 82 mm (around 35 mm nominally)
  - All other numbers huge
- Similar results when you use the D quads
- Reducing energy range by factor of 2
  - Cavity aperture down to 46 mm
  - Displacements still large

Current Lattice Specifications

- Detailed lattice specifications available at

http://www.conform.ac.uk/documents/emma/acc%20-%20accelerator%20physics/lattice.html

- Front page has geometry and parameters that encompass all configurations
- Individual configuration parameters linked from that page
- There's a data file containing tunes, times of flight, and orbit position at long drift center
- A subdirectory contains the output files from my design optimization